(19) Japan Patent Office (JP)

(12) Publication of Patent Application (A)

(11) Publication Number of Patent Application: JP-A-56-67884

(43) Date of Publication of Application: June 8, 1981

(51) Int.Cl.[3]:

G09F 9/35

G02F 1/133

G09F 9/00

Identification Number: 111

Itraoffice Reference Number

7013-5C

7348-4H

7129-5C

Request for Examination: not made

Number of Inventions: 1 (3 pages in total)

(21) Application Number Sho-54-144360

(22) Application Date: November 9, 1979

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(54) Title:

LIQUID CRYSTAL DISPLAY ELEMENT

Claims:

1. A liquid crystal display element, in which liquid crystal is held between a transparent substrate having a transparent electrode and a counter electrode disposed opposite thereto and at least having an integrated circuit including an MOS transistor for controlling an input signal, an MOS capacitor for storing an input signal and a display electrode, wherein one layer or multi-layer insulating material layer, at least the surface of which comes into contact with the display electrode is formed by a smooth high polymer resin layer, is disposed between an electrode of the MOS capacitor that is near the transparent substrate and the display electrode, and the electrode of the MOS capacitor that is near the transparent electrode and the display electrode electrically conduct through a through hole provided in a part of the insulating material layer.

2. The liquid crystal display element according to claim 1, wherein the high polymer resin is polyimide resin.

3. The liquid crystal display element according to claim

2, wherein the thickness of the polyimide resin is equal to or larger than 1 μm.

4. The liquid crystal display element according to claim 1, wherein the surface of the insulating material layer right under the high polymer resin that comes into contact with the high polymer resin layer of the multi-layer insulating material layer is smooth.

5. The liquid crystal display element according to claim 4, wherein the insulating material layer right under the high polymer resin layer is a glass layer which is melt-treated and contains at least a large quantity of phosphorus.

Detailed Description of the Invention:

This invention relates to a liquid crystal display element using a semiconductor substrate including individually addressable electrode arrays.

In recent years the liquid crystal element has been watched centering on a twisted nematic type display element, and used in a display part of a pocket calculator, a watch or a measuring device. As a liquid crystal display element of a new type, recently we have watched a liquid crystal display element having a semiconductor substrate including individually addressable electrode arrays.

Fig. 1 shows an example of a liquid crystal display element using a semiconductor substrate including

individually addressable electrode arrays. The liquid crystal display element using the semiconductor substrate is generally so constructed that the semiconductor substrate 14 having an MOS transistor 11 for controlling an input signal, an MOS capacitor 12 for storing an input signal and a display electrode 13, and a transparent substrate 16 having a transparent electrode 15 on the opposite side are disposed opposite to each other, and liquid crystal 18 is held in a gap formed by interposing a spacer 17 between both substrates, and in the thus constructed liquid crystal display element, an electric signal is applied between both opposite electrodes 13, 15, thereby scattering or modulating light radiated from the outside to display information.

It is, however, impossible to prevent irregular reflection of incident light due to the uneven surface necessarily caused in the traditional MOSIC manufacturing process. In the display method using light scattering of liquid crystal like a dynamic scattering mode using an n-type nematic liquid crystal or storage type liquid crystal display having a comparatively long relaxation time, which uses cholesteric-phase liquid crystal, the satisfactory contrast ratio of light scattering can not attained by on-off operation of applied voltage between both substrates because light scattering is caused by the above uneven IC surface. A method using surface smoothing insulating material as disclosed in

JP-A-53-72647 has been proposed in order to solve such a problem. According to an embodiment described in the above official gazette, a display electrode also serves as one electrode of a capacitor, and an insulating film under the light reflecting electrode is replaced with a smooth glass or polyimide smooth layer to be used as an insulating film of the capacitor, whereby the surface of the display electrode is smoothed to prevent irregular reflection of incident light, improving the contrast. In the case of using smooth glass for the insulating layer, however, a number of small projections called hillock are formed on the display electrode by sinter heat treatment generally performed after the display electrode is formed. Consequently, caused is the problem that the display electrode causes irregular reflection of incident light to lower the contrast of the liquid crystal display element.

In the case of using polyimide as an insulating layer, it is necessary to make the film thickness of polyimide enough large for forming a film without a pinhole, and the capacity of a capacitor becomes small. As a result, the quantity of charges to be stored in the capacitor is small so that the signal voltage can not be kept for a long time due to leak current flowing through the liquid crystal and the transistor, the effective voltage applied to the liquid crystal is lowered, satisfactory light scattering is not caused to lower the contrast, and the response speed of liquid crystal becomes low.

The invention has been made in the light of the above disadvantages of the prior art to provide a liquid crystal display element which has superior display quality and high reliability and has a semiconductor substrate including individually addressable electrode arrays by separately providing a capacitor electrode and a display electrode, and disposing a high polymer resin layer having the smooth surface right under the display electrode.

According to the invention, the display electrode and the capacitor electrode are separately disposed, whereby the film thickness of an insulating film between both electrodes can be made large enough so that an insulating film having no defect can be made, and further the film thickness of a high polymer resin layer can be made large so that the uneven ground is made good by filling a gap to make an enough smooth surface. Further, as an insulating film layer between both electrodes of the capacitor, a thermal oxidation film of silicon, which is denser than the high polymer resin so that even if it is thinner, no pinhole is generated, can be used so that the capacitor can be increased enough in capacity. Accordingly, since the quantity of charges stored in the capacitor is enough large, the leak charge quantity is a small matter, and the effective voltage for driving the liquid crystal becomes large so as to improve the contrast and response time. Accordingly, it is possible to manufacture a liquid crystal display element

having good display quality and having a semiconductor substrate including individually addressable electrode arrays.

Embodiments of the invention will now be described concretely with reference to the attached drawings.

Fig. 2 is a diagram showing one embodiment of the invention. An insulating film 23 between both electrodes 21, 22 of a signal charge storage capacitor is a thermal oxidation film of silicon made carefully not to generate any pinhole, and the thickness thereof is 1000Å. In the case of using polyimide resin as the insulating film 23, in order to form an insulating film without pinhole, it is necessary to set the thickness to about 1 μm. The insulating film is replaced with the silicon thermal oxidation film 1000Å thick, whereby the capacity of the capacitor can be increased by ten times. Further, a polyimide resin insulating layer 26 is disposed with a thickness of 2 μm between one electrode 22 of the capacitor and a display electrode 24, and further a thorough hole 27 is provided so that the capacitor electrode 22 and the display electrode 24 electrically conduct. When the thickness of the polyimide film is under 1μm, the uneven ground is not enough flattened. In the case of a thickness equal to or larger than 1 μm, however, the ground is considerably smooth, and in the case of a thickness of about 2μm, an enough smooth surface can be obtained.

When Al is deposited 2 μm on the polyimide resin insulating layer, a very smooth Al surface like a mirror-finished surface can be obtained. A liquid crystal display element is manufactured by the semiconductor substrate manufactured under the above conditions and a transparent substrate having a transparent electrode conductive film, and display tests have been made. It is found from the tests that the electro-optic response time is fast as much as 50 ms, and the contrast is 20 : 1 so that the display performance is practical to use. The electric contact between the capacitor electrode and the display electrode is made only at the central part as illustrated, but if the positions are opposite, any part will do.

Fig. 3 shows another embodiment of the invention. An insulating film 33 between both electrodes 31, 32 of a signal charge storage capacitor 34 is a silicon thermal oxidation film 1000Å thick, a PSG layer 37, the surface of which is smoothed by melt treatment, is provided on one electrode 32 of the capacitor, and further a polyimide layer 38 is provided thereon. A display electrode 39 and the capacitor electrode 32 are forced to electrically conduct by a through hole 36. It is well known that the melt-treated surface of the PSG is very smooth. The surface of the polyimide resin layer is made more smooth than the case without a melt-treated PSG layer by providing the melt-treated PSG layer under the polyimide resin layer, and

the surface of the display electrode 39 where Al is deposited on the resin layer becomes a smooth mirror finished surface. A liquid crystal display element has been manufactured by the semiconductor substrate and a transparent substrate having a transparent electrode and display tests have been made. The test result shows that the contrast is very good as much as 25:1.

According to the invention, as described above, the semiconductor substrate having both the large-capacity signal charge storage capacitor and the smooth display electrode can be obtained, so that it is possible to manufacture the liquid crystal display element having a large contrast ratio and high reliability and using a semiconductor substrate including individually accessible electrode arrays.

Brief Description of the Drawings:

Fig. 1 is a diagram for explaining a liquid crystal display element using the conventional semiconductor substrate;

Fig. 2 is a diagram showing one embodiment of the invention; and

Fig. 3 is a diagram showing another embodiment of the invention.

25, 35: MOS FET 21, 31: one capacitor electrode 22, 32: the other capacitor electrode 23, 33: insulating material

between both electrodes of the capacitor 27, 36: through hole 26, 38: polyimide layer 24, 39: display electrode 37: PSO layer to which melt treatment is subjected.